

A Mid-Holocene Strandline Deposit on the inner shelf of Cochin, West Coast of India

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Abstract. Beach sediments with a phi mean size varying from 1.07 to 2.9 are well to moderately sorted and to a great extent negatively skewed. On the inner shelf, the sediments exhibit a wide range (0.9 ϕ and 10 ϕ) in mean grain-size. While most of the inner shelf is covered with fine silts and clays, sandy sediments occupy a linear belt in the outer parts (-25 to -30 m) of the shelf. These moderately sorted sands are considered to be relict and deposited during a standstill of the Holocene transgression. The CM pattern suggests that the sandy sediments in the inner shelf like the beach sands were deposited under high energy conditions. The well-preserved sands indicate that the existing hydrodynamic conditions on the inner shelf are neither strong enough to rework the sediments nor transport the modern river-contributed fine sediments to the outer parts.

Keywords: Continental shelf, Holocene Transgression, Strandline deposit. West Coast, Cochin.

INTRODUCTION

It has long been recognized that the West Coast of India represents a drowned coast (Nair, 1974) and the rise in sea level due to Late Pleistocene deglaciation affected continental shelf sedimentation. The Holocene transgression permitted a variety of terrestrial and marine processes to operate over the shelf with the result the nature of the shelf sediments varied significantly with rise in sea level and changing climatic conditions. Submerged reef and shoal carbonates up to -50 m (Nair *et al.* 1979) occur over a great part of the outer shelf. These calcareous sediments were relict deposits (5000-11000 YBP) formed at a time when the sea level was lower than at present. With the sea level reaching the present position and perhaps with changing climatic conditions and slowing of the sea-level rise, terri-

genous clastic sedimentation dominated the inner shelf. Thus, on the continental shelf, relict calcareous sediments on the outer shelf grade into the modern clastic deposits on the inner shelf (Hashimi *et al.* 1978; Hashimi and Nair, 1981). Even though the general increase in the sea-level and shifting of the coastline has been established, the shoreline positions on the shelf and the rate of rise in the sea-level were not discussed by any of the earlier investigators studying the western continental shelf of India. In most passive margin shelves of the world, Holocene lowstand shorelines were identified at varying depths on the shelves (Franzier, 1974). Recently, Mohana Rao *et al.* (1989, 1990) and Srinivasa Rao *et al.* (1990) reported the occurrence of coarse sand deposits in the deeper parts of the inner shelf on the east coast of India and

considered that these sediments were formed during a Holocene stagnation of the sea level at that depth. Such findings indicate that the Holocene transgression was episodic but not a smooth asymptotic rise (Fairbridge, 1961). Inspired by the above studies, authors have made an attempt to document the Holocene sea-level trends on the West Coast of India. For this purpose the investigation of inner shelf sediments of Cochin coast has been undertaken.

THE STUDY AREA

The continental shelf of Cochin coast (Fig. 1) is relatively smooth with depth contours running almost parallel to the present coastline. The featureless inner shelf has an average slope of 8.5° . A characteristic feature of the study area is the occurrence of mud banks in the coastal zone off Cochin and Alleppey, particularly during SW monsoon period (Gopinath and Qasim, 1974; Nair, 1976). An elongate barrier complex separates the shelf from the adjacent Vembanad Lake. A number of small rivers join this lake before emptying onto the shelf. In the northern part, the Periyar river is a major contributor of sediment to the shelf, particularly during the SW monsoon period. The sandy beaches are narrow and possess a low profile in general. The coast is exposed to seasonally changing winds such as southwest winds during May-September and northeast winds during December-March. Semi-diurnal tides with their range less than 2 m prevail along the coast. Prasanna Kumar and Murty (1987) state that flat inshore bottom topography with localised static mud suspensions and undersaturated littoral flows give rise to erosion of existing beaches.

MATERIALS AND METHODS

Bottom sediment samples from the inner shelf (Fig. 1) were collected using

Van Veen and Peterson grab during cruises on the research vessel NAUTILUS of Cochin University. In the Vembanad lake and Periyar river, grab samples were collected using small local boats. Beach samples were obtained with a plastic scoop.

The samples were prepared for size analysis by desalination and dispersion in sodium hexametaphosphate. Both sieving and pipette analyses were used in obtaining various grain-size fractions of the sediments. Sieves were arranged with $1/2$ phi intervals and kept on \bullet -tap for about 20 minutes. Statistical grain-size parameters of Folk and Ward (1957) were calculated by computer using the weights of different size grades. A triangular diagram (Shepard, 1954) was used to represent the sand, silt and clay ratios of the sediments. CM diagram (Passega, 1957) was drawn using the data of first percentile (C) and median (M) of the grain-size distributions.

RESULTS

Sand-Silt-Clay

Sand, Silt and Clay per cents of the inner shelf sediments are shown in a triangular diagram (Fig. 2). Grain-size distributions are not clustered tightly but have a wide-spread trend in all the three variables. However, they are slightly skewed towards the silt mode with clayey silts dominating the other sediment types. Regional distribution of the grain-size modes shows that the inner shelf is veneered with a complex mosaic of sediment types rather than a simple seaward fining sheet. The sediments of the beach are sands which extend only to a short distance into the littoral zone from the shore. From -3 m, depth contour the clay-fraction increases with depth and distance from the coast up to about -25 m. However, the increase is not uniform but varies from place to place on the inner shelf. Between

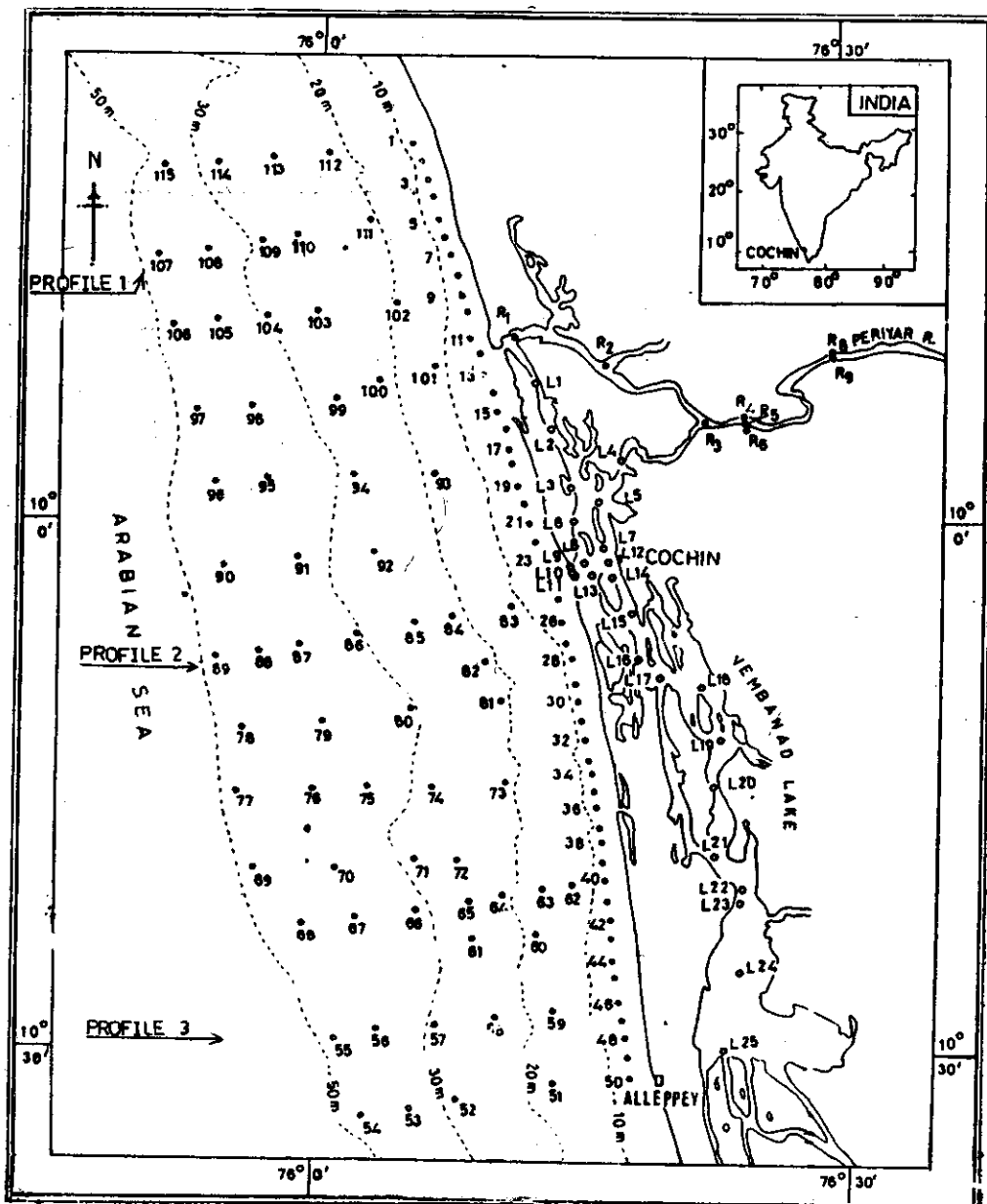


Figure 1. Sample locations in the inner shelf of Cochin, Periyar River and Vembanad lake, West Coast of India.

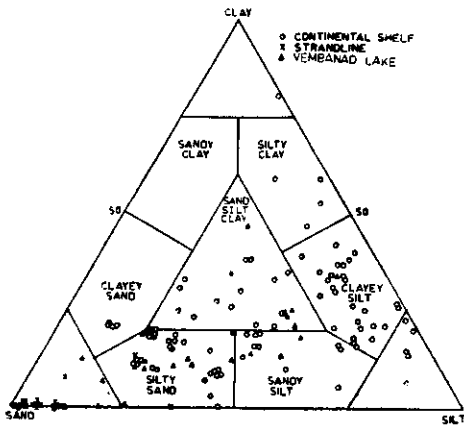


Figure 2. Sediment textural types in the innershelf and Vembanad Lake.

-25 and -30 meters, sandy sediments, which are comparable in size to the beach sands, occur. Sand percentages of the samples from three selected profiles plotted against distance indicate the presence of a coarse sand zone at approximately 20 km from the present shoreline (Fig. 3).

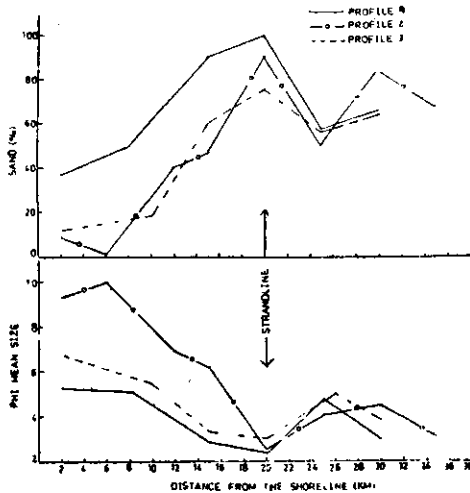


Figure 3. Phi Mean size and sand per cent of shelf sediments from three selected profiles plotted against distance from the shoreline.

These sediments with a sand per cent as high as 98, grade gradually offshore into

sandy silt and clayey silt until coarse carbonate sediments are met with at -50 m depth contour.

Modern sediments of the Vembanad lake are predominantly sands and silty-sands in the south and sandy-silts and sand-silt-clays at the mouth in the north. The sediments of the Periyar river, which is one of the sources of the sediments of the inner shelf, are mostly coarse sands.

Mean size

The phi mean grain-size of the beach sediments ranges between 1.07 and 2.93 (Table I). Though there is a wide variation in the mean size, no systematic trend in distribution is observed. The mean size of the inner shelf sediments varies from 0.9 ϕ to 10 ϕ . Sandy sediments (0.9 ϕ to 4 ϕ) are confined to the outer parts of the inner shelf, whereas the rest of the shelf is covered with fine sediments. In the Vembanad lake, there is a general decrease in the mean grain-size of the sediments from south to north. Coarse sediments (1 ϕ to 2.5 ϕ) in the south grade into fine silts in the northern end of the lake, where it joins the sea. The Periyar river sediments are relatively coarse than the sediments in the other environments with a phi mean-size varying from -0.5 to 1.43. The coarse sands upstream gradually grade into fine-sands downstream.

An overall distribution pattern of the mean-size shows that the sandy sediments in the inner shelf and in the southern part of the Vembanad lake exhibit more or less the same grain-size. The river sediments are, however, relatively coarser. The fine silts at the northern end of the lake near the confluence are comparable with the fine inner shelf sediments.

Sorting and Skewness

Beach sands and shelf sands are well to moderately sorted and negatively

TABLE I. Ranges of grain-size parameters of sediments from different environments of Cochin coast.

Environment		Parameters					
		Mean-size (M_z)	Standard Deviation	Skewness SK	Sand %	Silt %	Clay %
Inner shelf	Outer	0.9 - 4.0	0.63 - 2.9	- 0.52 - 0.63	50 - 100	0 - 46	0 - 20
	Rest	4.0 - 10	0.15 - 4.05	- 0.33 - 0.76	5 - 67	0 - 70	0 - 81
Beach		1.07 - 2.9	0.43 - 1.15	- 0.5 - 0.61	98 - 100	0 - 1.73	—
Vembanad Lake		1.0 - 6.1	1.2 - 3.6	- 0.02 - 0.65	24 - 100	2 - 56	0 - 47
Periyar River		- 0.5 - 1.4	0.44 - 1.7	- 1.15 - 0.3	95 - 100	0 - 4	0 - 3

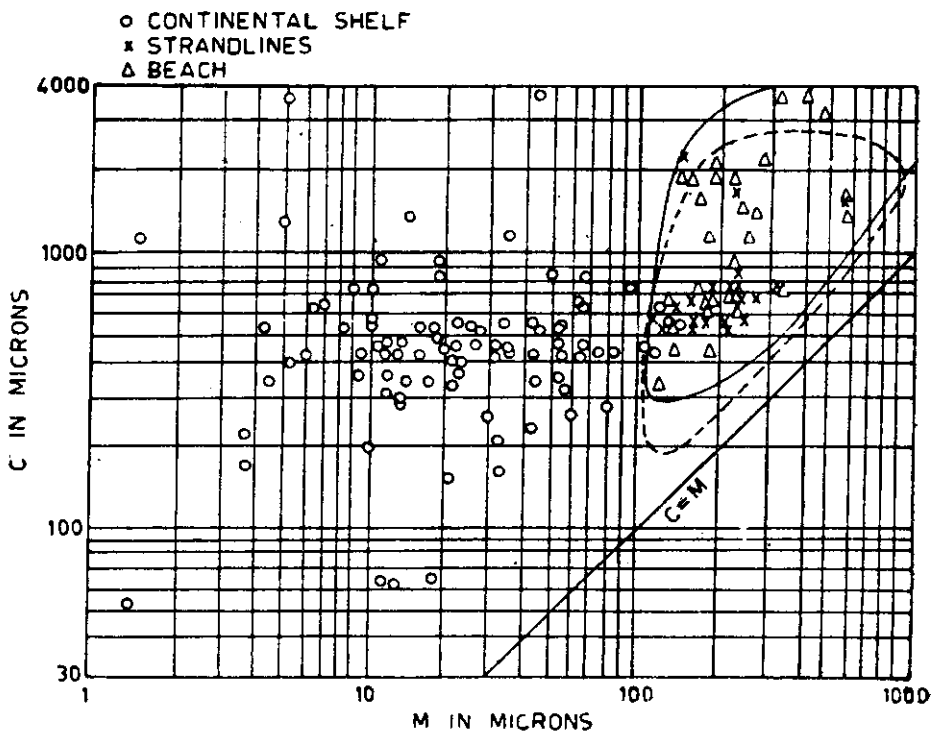


Figure 4. C-M pattern of the Beach and inner shelf sediments. Dashed lines indicate the beach zone after Passega (1957).

skewed to a great extent (Table I). The river sands exhibit better sorting with standard deviation values between 0.44 to 1.7. Fine shelf-sediments are poorly sorted and both negatively and positively skewed. However, majority of the sedi-

ments exhibit positive skewness. In Vembanad lake, though the sediments are poorly sorted, the coarse sediments are relatively better sorted than the fine ones. A great number of lake sediments are positively skewed.

C-M diagram

In the C-M diagram (Fig. 4), beach and coarse strandline sands are located in the beach zone specified by Passega (1957) and have an elongate distribution almost parallel to the C-M line. However, some of the sediments are close to the line, while others slightly away from it show a difference in the sorting of the sediments. The other shelf sediments are scattered through a wide area between $C=1000$ microns and $M=100$ microns and away from the C-M line in a horizontal trend.

DISCUSSION

The transgressive sediments on the inner shelf consists of a stillstand deposit of coarse sands and shallow marine fine silts and clays. Well- to moderately-sorted beach sands extend only a few meters offshore. The fact that the textural patterns developed during stillstand have not been much obliterated shows that the modern hydrodynamic processes on the inner shelf are not intense enough to modify the sediments. As indicated by the sediment distribution pattern, modern sediment deposition seems to be active only up to -30 m with sands depositing in the shoreface and silty clays and clayey silts offshore. The C-M pattern also indicates low-energy conditions in most part of the shelf, where fine sediments were deposited. From textural characteristics and inconsistency in their occurrence in relatively low energy conditions, coarse sands in the outer parts of the inner shelf are considered to be a stillstand deposit of the Holocene transgression. Further, the C-M pattern shows that the sandy sediments were deposited under high energy conditions probably similar to those existing on the present day shoreface. It appears that the Holocene transgressive sea paused for a time at about -30 m. During this stagnation period, sandy sediments were deposited at the shoreline and

fine sediments were carried offshore. With the resumption of perhaps rapid rise in sea level, and associated submergence, the shoreline migrated landward leaving the coarse sand as a lag deposit. Prithviraj and Prakash (1991) from the granulometric and multivariate analysis of detrital quartz grains of the inner shelf sediments of central Kerala coast inferred that the sands of outer-inner shelf are the beach deposit of Holocene period. Curray (1960) and Morton and Winker (1978) state that the Paleoshorelines formed during brief lulls in the Holocene transgression can be delineated by abnormally high concentration of coarse sediments. Mid-Holocene strandlines were identified on the shelf of east coast of India between $25-30$ m depth based on the occurrence of coarse sediments (Mohana Rao *et al.*, 1989, 1990). Srinivasa Rao *et al.* (1990) ascribed an age of about 7500 years B. P. for the stillstand deposit occurring at -20 m in Nizampatnam Bay, East Coast of India.

CONCLUSIONS

The inner shelf sediments of the Cochin coast do not exhibit a general seaward fining of the particle size from the coast. The lens of coarse sands at about -30 m water was evidently deposited during a stillstand of the Holocene transgression at that level and, therefore, is relict in nature. The existing hydrodynamic conditions on the inner shelf are not strong enough either to rework the coarse sediments or transport the modern terrigenous fine sediments to the outer parts. By analogy with similar finds on the east coast of India and the chronological data (8960 years for -82 m) of Nair *et al.* (1979) on western shelf sediments, it is inferred that the Holocene sea level paused at a depth of -30 m about 7500 years B.P. We strongly suggest further detailed investigations on the inner-shelf in other parts of the West Coast to confirm and

evaluate the age of this standstill of the Holocene transgression.

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